

# Z(ee) + $\geq n$ Jets xsection

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- Overview (Samples, selection criteria, ...)
- Corrections (EM, Trigger, Tracking, ...)
- Data vs MC comparisons
- Xsection unsmearing
- Z(ee) +  $\geq n$  Jets xsection
- Systematics
- todo



# Samples

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- **Data:**
  - Lumi = 342.885 pb<sup>-1</sup>
  - Run range: 20 April 2002 - 28 June 2004 (Runs 151,817 - 194,566)
  - Pass 2 (T42 enabled)
  - JES 5.3
  - EM1TRK skim
  - Single EM triggers
  - Rejecting bad runs (CAL, SMT, CFT, Jet/Met, Lumi)
  - Processed with ATHENA (p16-br-03)
- **MC:**
  - $Z/\text{Gamma}^*$  → e<sup>+</sup>e<sup>-</sup>+X: 400k Pythia
  - $Z_j \rightarrow ee j$ : 150k Alpgen + Pythia
  - $Z_j \rightarrow ee jj$ : 180k Alpgen + Pythia
  - $Z_{jj} \rightarrow ee jjj$ : 15k Alpgen + Pythia
  - Processed with ATHENA (p16-br-03)



# Selection Criteria

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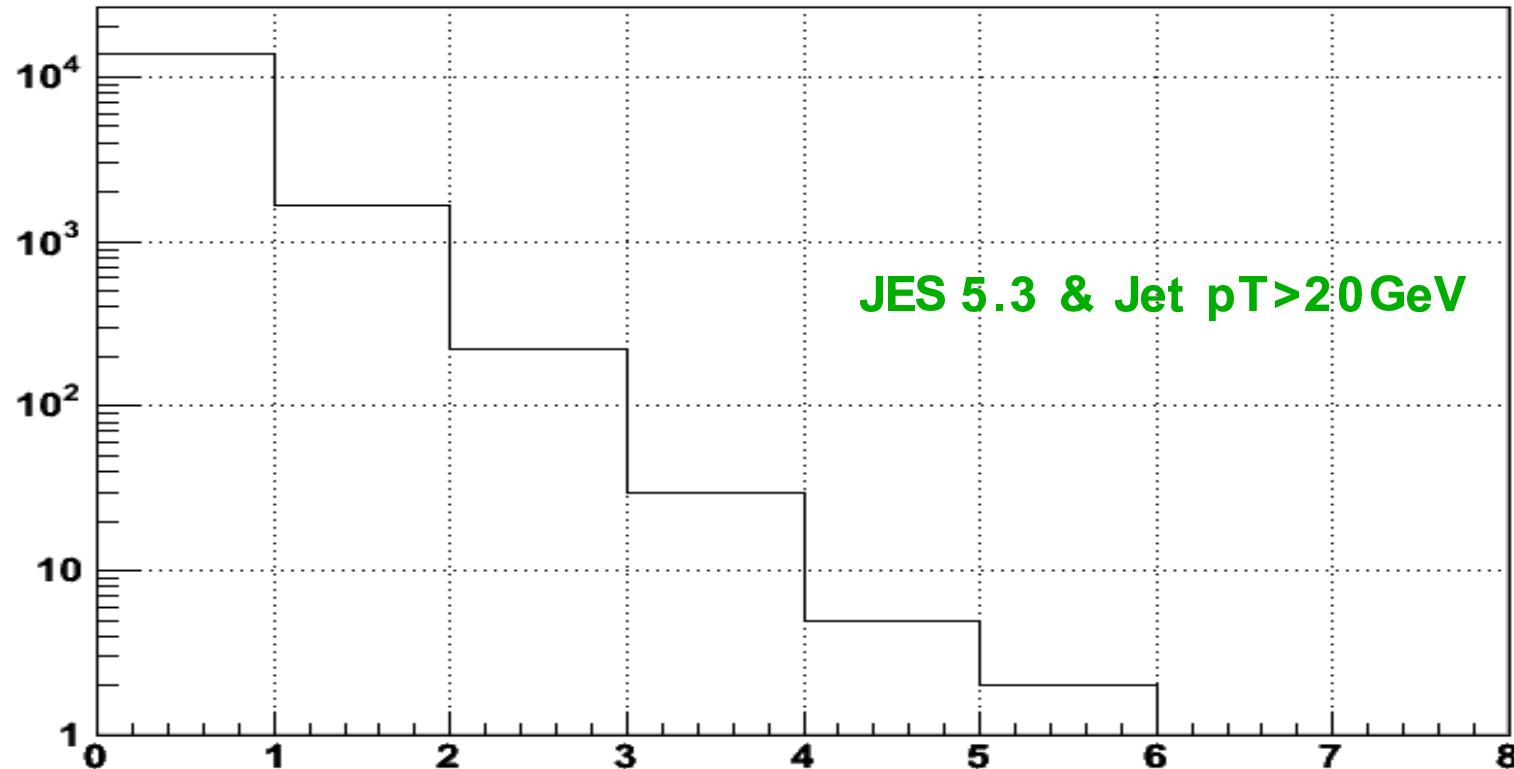
- Removing bad runs/LBNs & dupli events
- PVX cut:  $|z|<60\text{cm}$
- Using unprescaled single EM triggers
- Electron selection:
  - $|\text{ID}|=10,11$
  - $\text{EMF}>0.9$
  - $\text{Iso}<0.15$
  - $\text{HMx}(7)<12$
  - $p_T>25\text{GeV}$
  - $|\text{det\_eta}|<1.1$
  - Including phi cracks
- Z selection:
  - $75\text{GeV} < M_{ee} < 105\text{GeV}$
  - At least one trackmatched electron
  - At least one electron needs to fire the trigger
- Jet selection:
  - $0.05 < \text{EMF} < 0.95$
  - $\text{HotF} < 10$
  - $\text{N90}>1$
  - $\text{CHF}<0.4$
  - L1conf
  - JES corrected  $p_T>20\text{GeV}$
  - $|\text{det\_eta}|<2.5$
  - Removal of jets overlapping with electrons from Z within dR of 0.4



# Jet Multiplicities

Inclusive Jet Multiplicities

(Data)



Inclusive # of jets

# events (uncorr)



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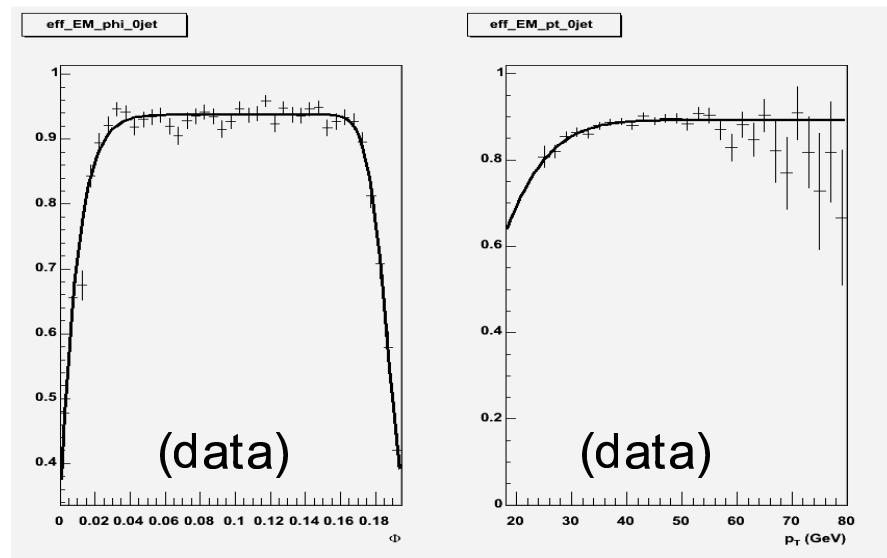
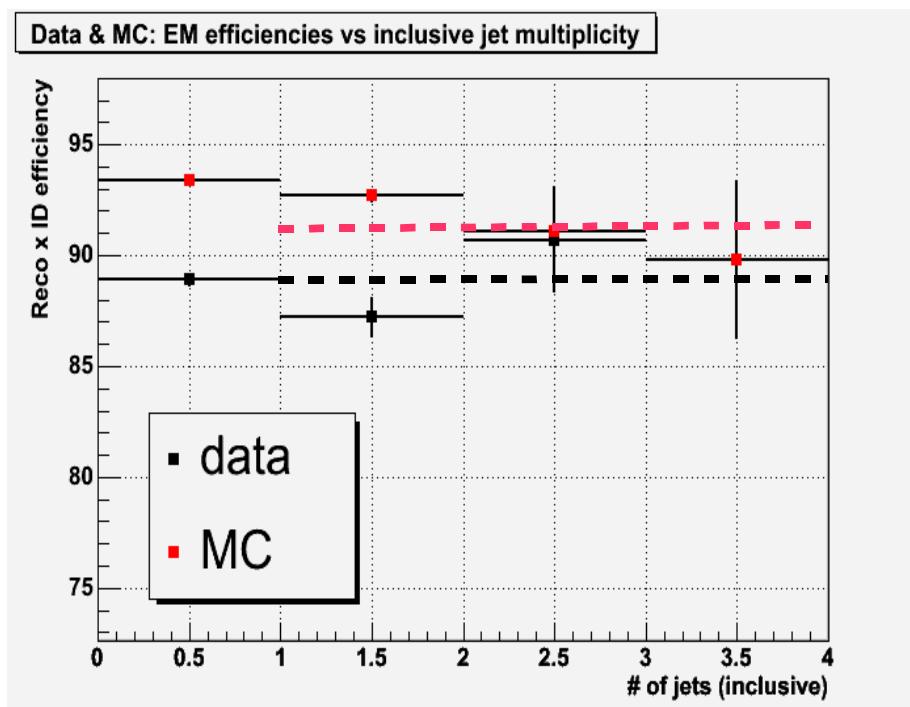
# Corrections

- EM
- Trigger
- Tracking
- Z pT
- Jet Reco
- Acceptance



# EM Correction

- Using a tag-and-probe method:  
tag = tight electron, probe = track
- We derive parameterized (vs pT  
and Phi) efficiencies for Z(ee)+X  
sample

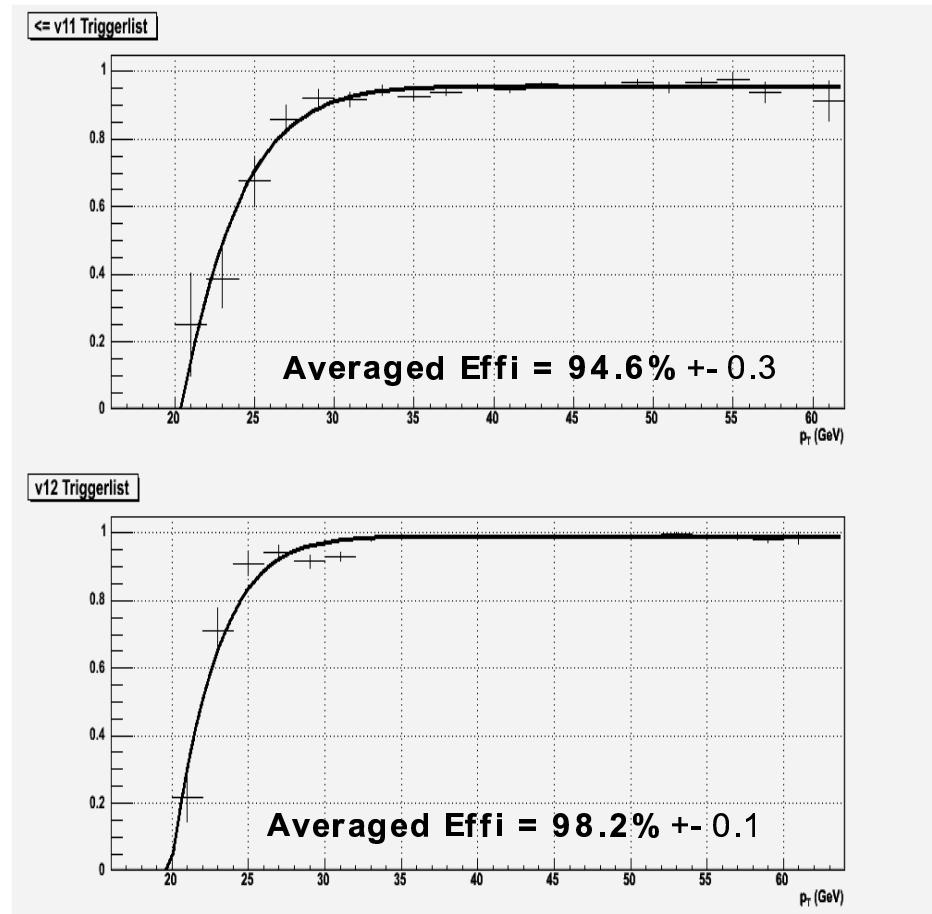


- We apply the parameterized efficiency curves as corrections (weights) to all jet multiplicity samples
- Using averaged efficiencies we correct for residual inefficiencies for the  $\geq 1, 2, 3, 4, 5$  jet samples



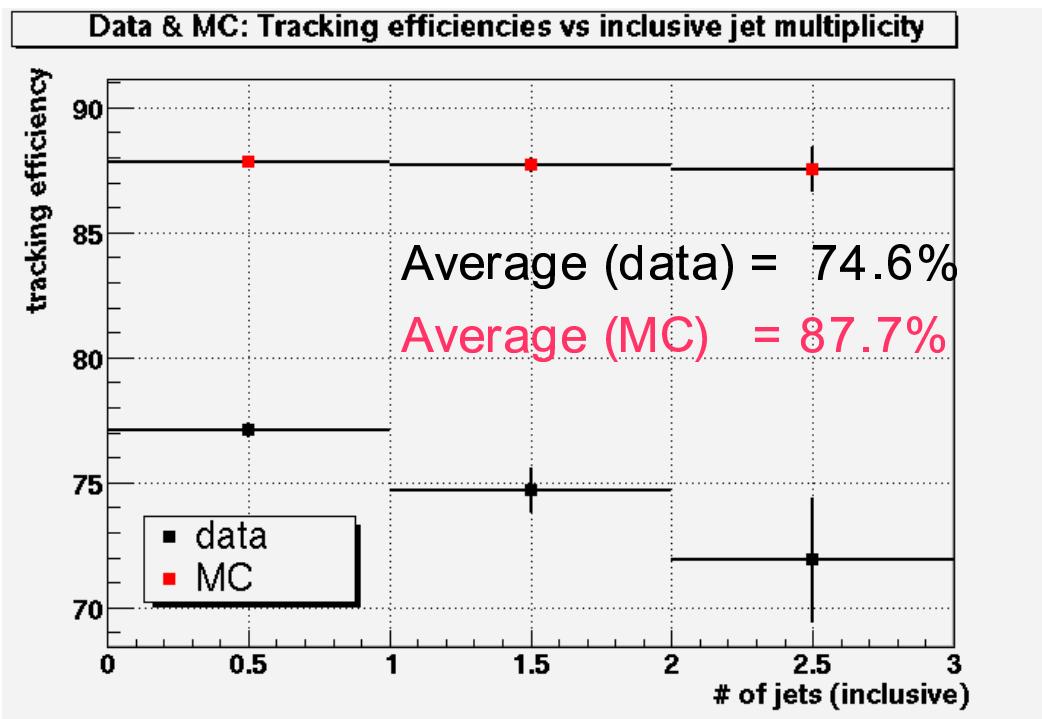
# Trigger Correction

- Method: tag-and-probe method, where the probe electron is tested for matching trigger objects at L1, L2 and L3
- Need to separate trigger efficiencies for pre-v12 and v12 data
- No big variations in averaged trigger efficiencies vs jet multiplicity observed
- Applying trigger efficiency vs  $p_T$  as corrections (weights) to all jet multiplicity samples



# Tracking Correction

- Method:
  - # of signal events in  $M_{ee}$  histogram when requiring 1 track match
  - # of signal events in  $M_{ee}$  histogram when requiring 2 track matches
  - Take the ratio to get an averaged efficiency

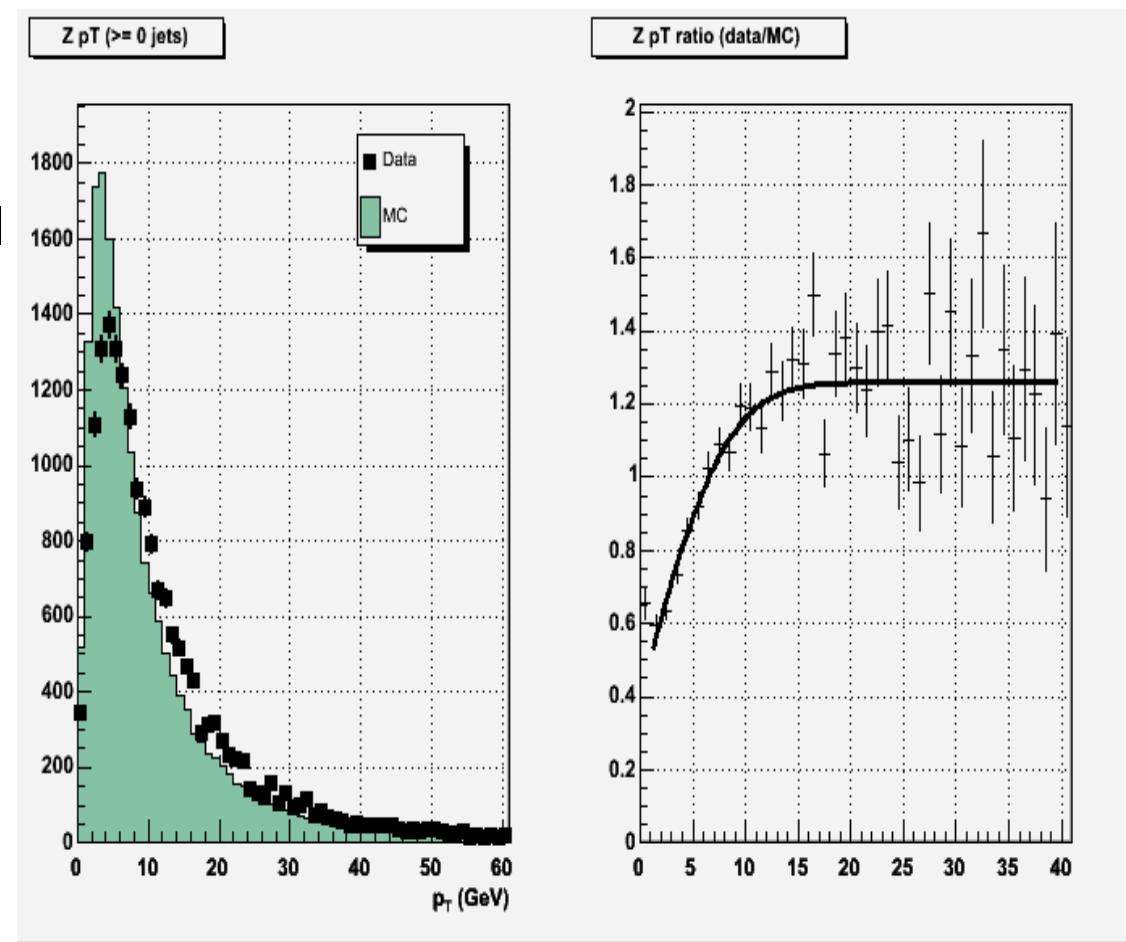


- Applying the averaged efficiency as corrections (weights) to all jet multiplicity samples



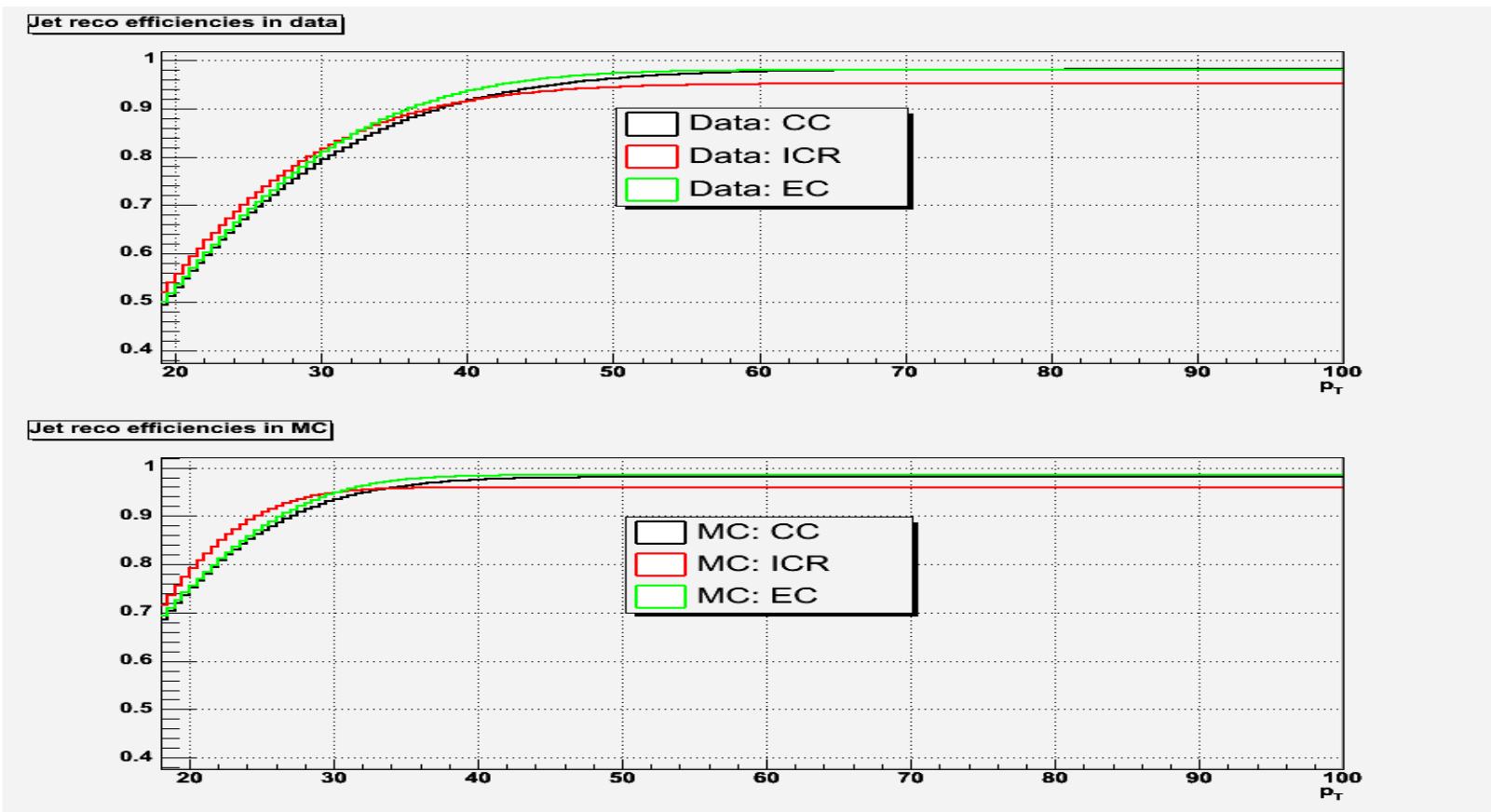
# Z pT Correction

- Needed to adjust Pythia MC to data
- After applying all the previous corrections we compare the Z pT between data and MC
- We take the ratio of data over MC and apply it as an additional correction to the Pythia MC
- Not needed for Alpgen samples



# Jet Reco Correction

- Based on work done by James Heinmiller
- Straight Reco x ID efficiencies for MC and data (= MC x scaling factor)



# Acceptance Correction

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- Kinematic and geometric efficiency for Z's
  - $|PVZ| < 60\text{cm}$
  - 2 electrons with  $pT > 25\text{GeV}$ ,  $|\text{det\_eta}| < 1.1$
  - $75\text{GeV} < M_{ee} < 105\text{GeV}$
- Vs jet multiplicity based on the number of p.l jets with  $pT > 20\text{GeV}$ ,  $\text{det\_eta} < 2.5$

$$\text{Acc} = \frac{\text{\# of CAL Z's with } n \text{ p.l. jets } (pT > 25, |\text{eta}| < 2.5)}{\text{\# of p.l. Z's with } n \text{ p.l. jets } (pT > 25, |\text{eta}| < 2.5)}$$

Jetmult	Acceptance
0	21.0%
1	23.7%
2	25.4%
3	27.8%
4	28.6%
5	30.9%



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# Data vs MC

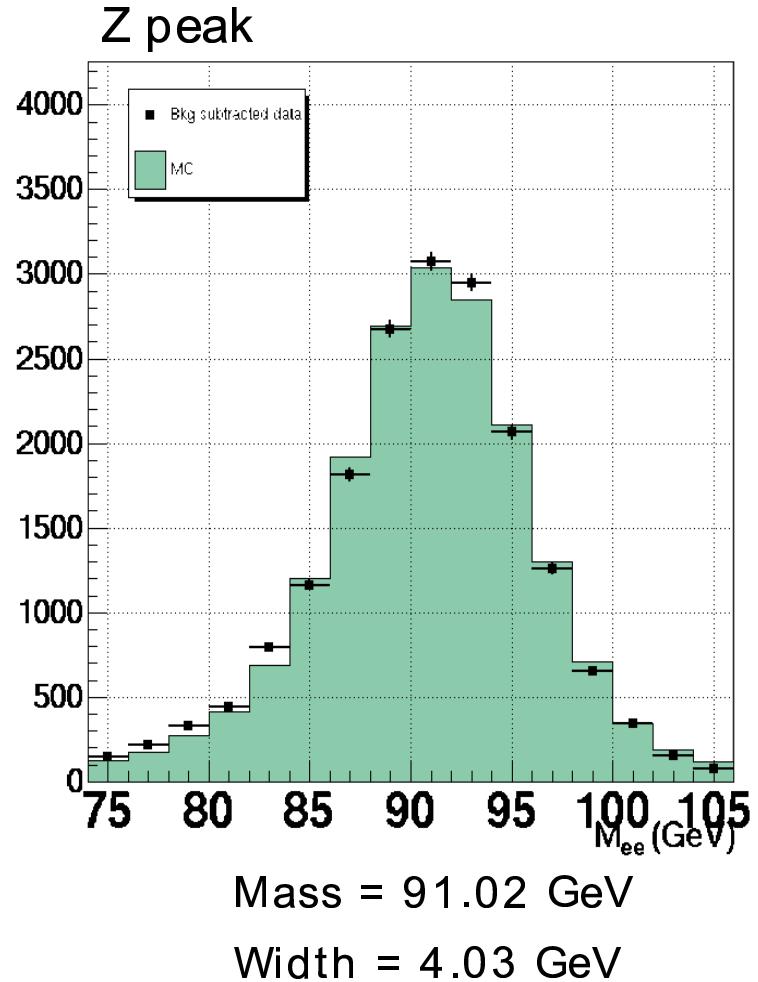
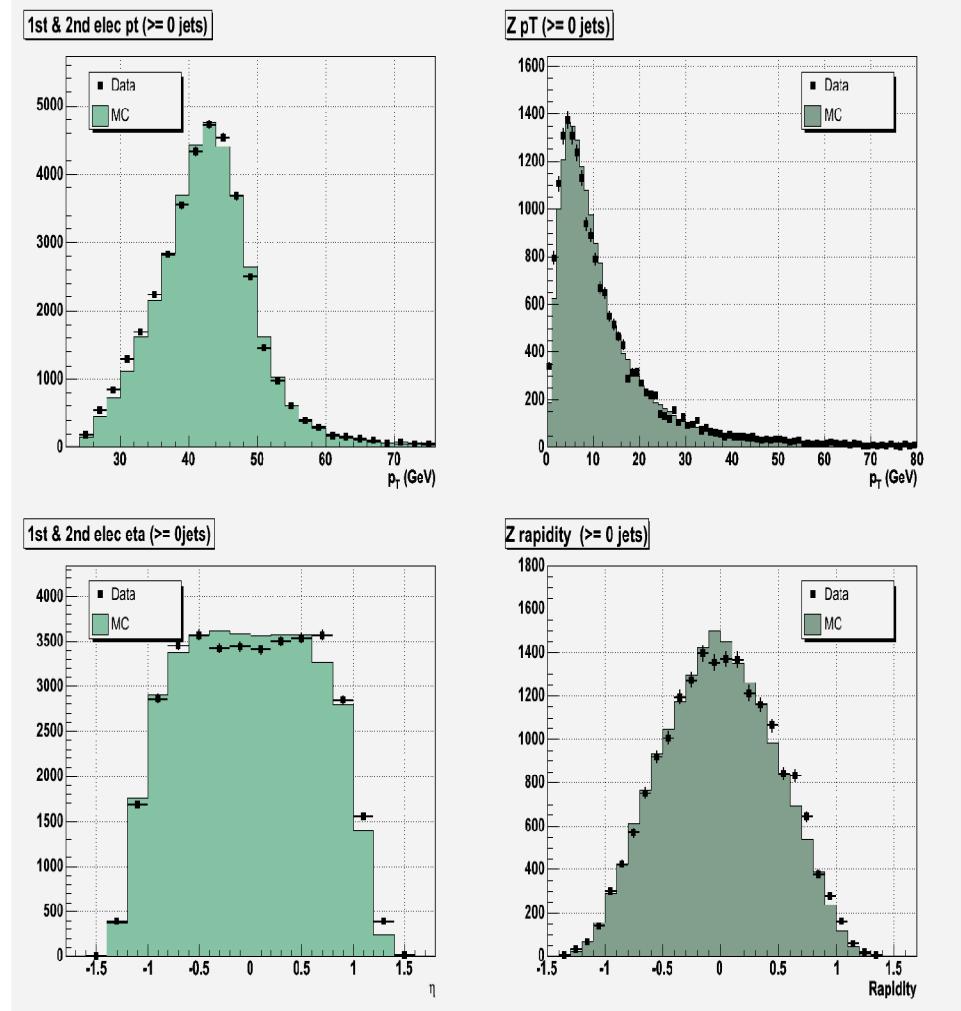
- Applying corrections: EM, Trigger, Tracking, Z pT, Jet Reco scaling
- Normalized wrt area



# Z(ee)+X: Electrons and Zs

Sample size  $\approx 14k$  events

MC = Pythia



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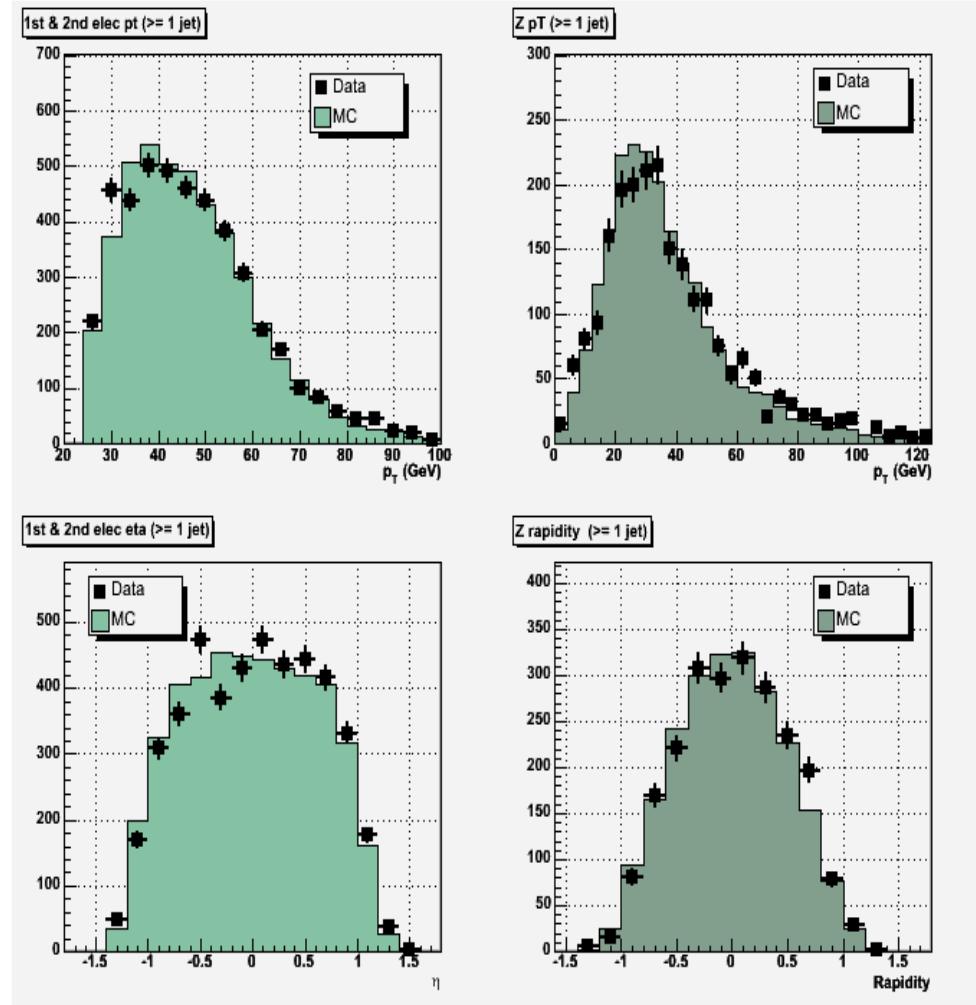
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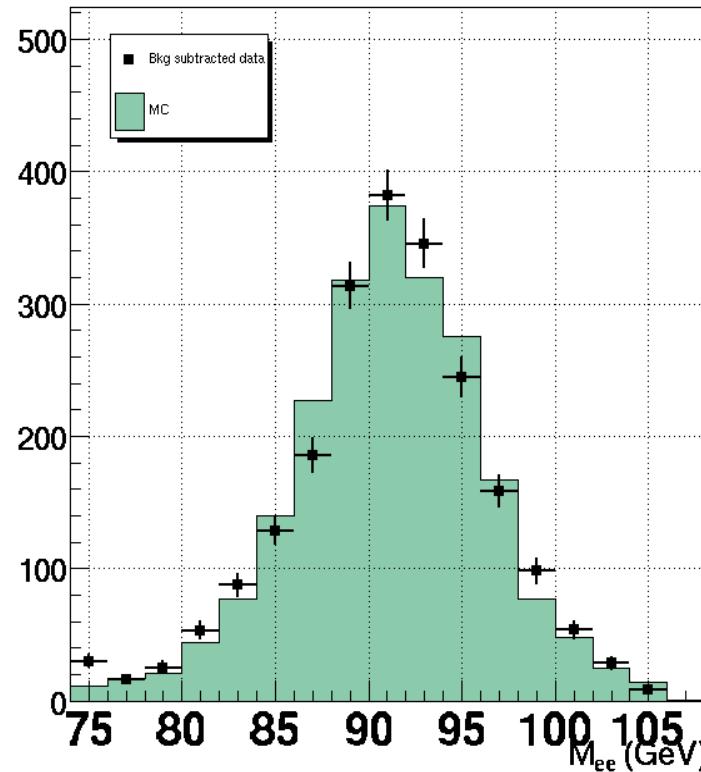
# $Z(ee) + \geq 1\text{jet(s)}$ : Electrons and Zs

Sample size  $\approx 1.7\text{k}$  events

MC =  $Zj$  Alpgen



Z peak



Mass = 91.40 GeV

Width = 4.09 GeV



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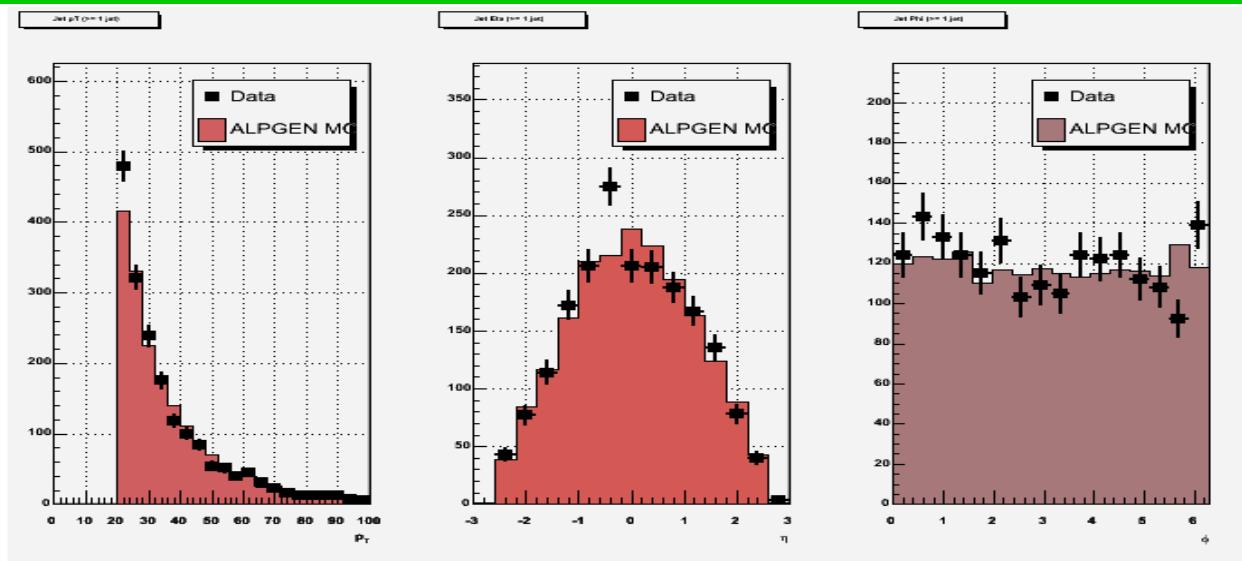
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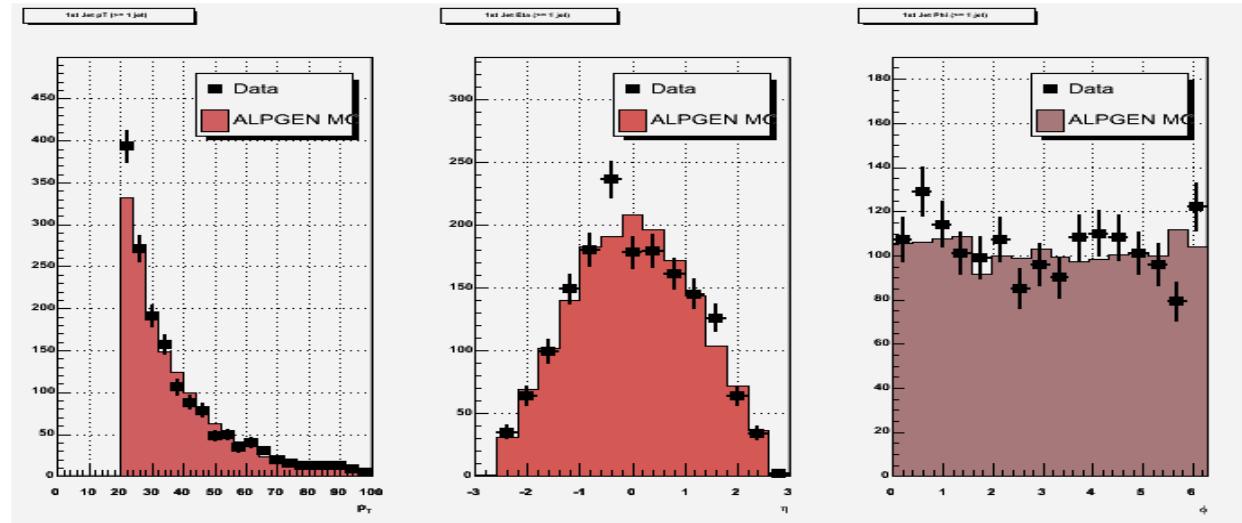
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# $Z(ee) + \geq 1\text{jet(s)}$ : Jets

All Jets



Lead Jet



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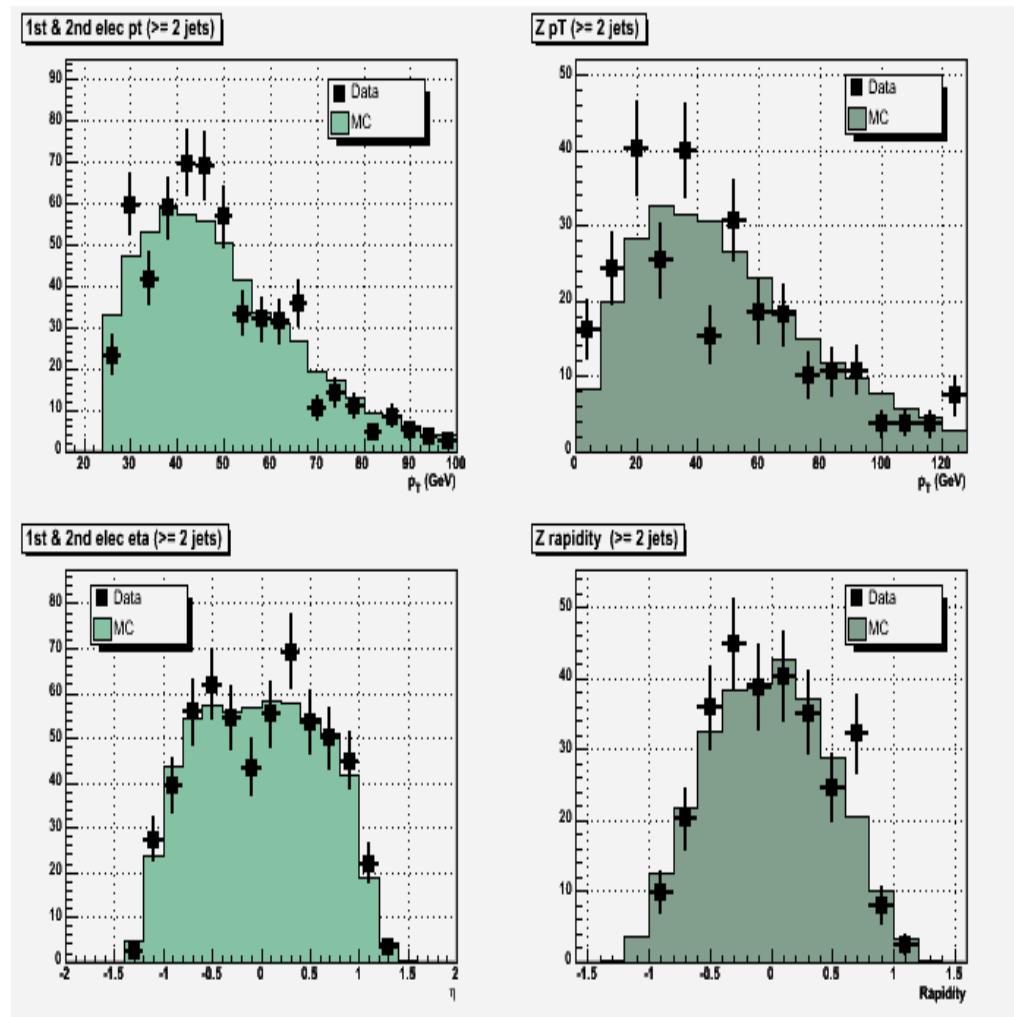
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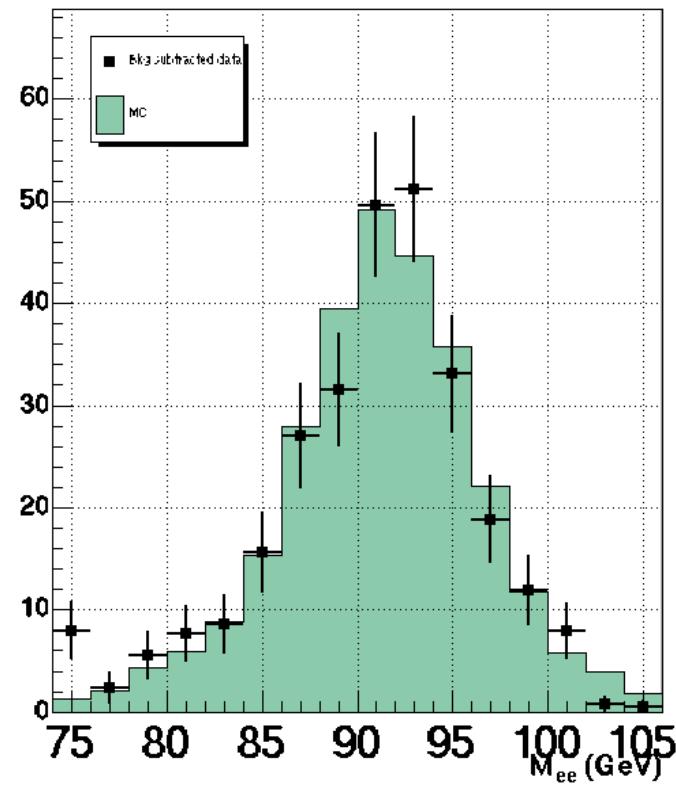
# $Z(ee) + \geq 2\text{jet(s)}$ : Electrons and Zs

Sample size  $\approx 200$  events

MC =  $Zjj$  Alpgen



Z peak



Mass = 91.47 GeV

Width = 3.72 GeV



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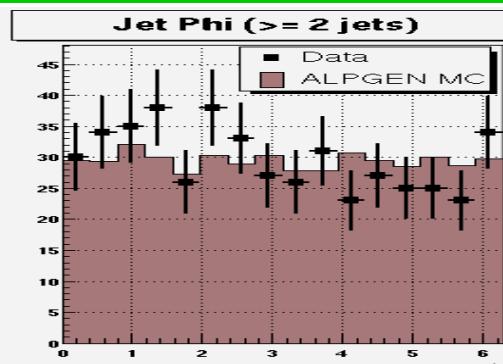
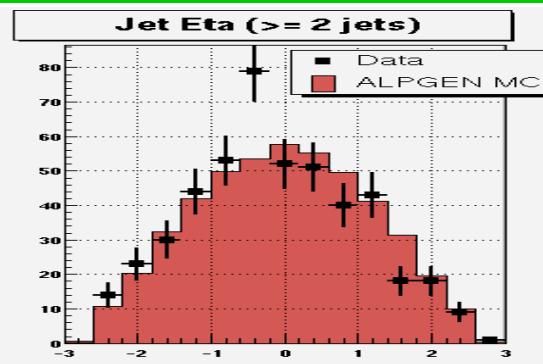
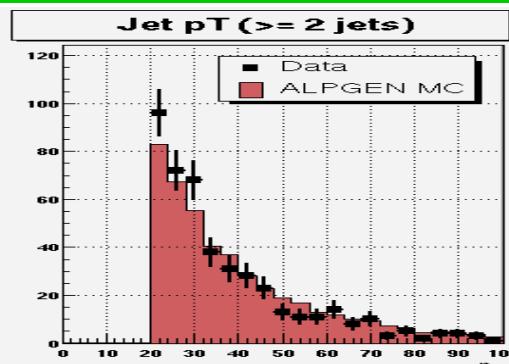
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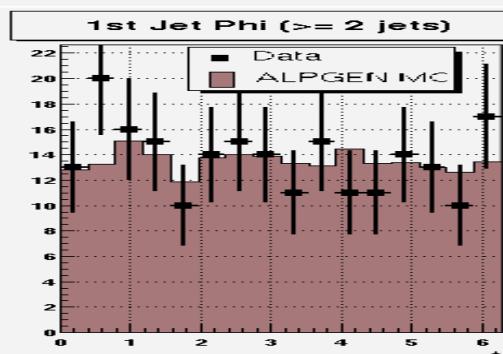
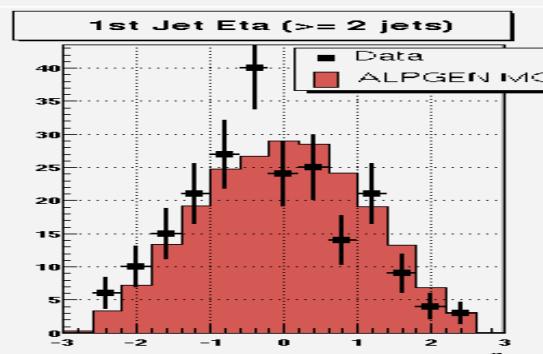
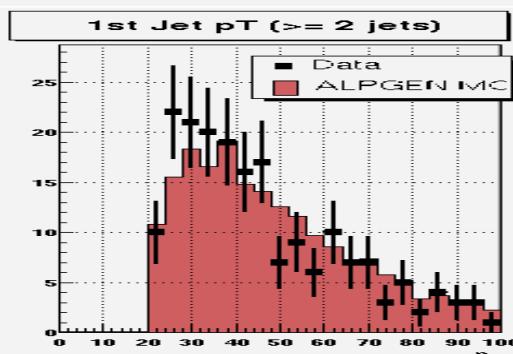
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# $Z(ee) + \geq 2$ jet(s): Jets

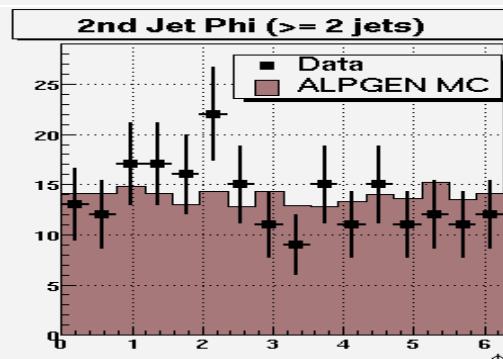
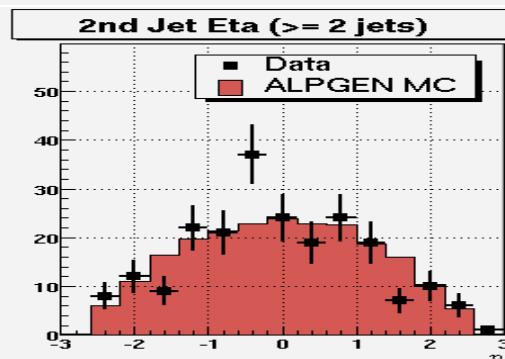
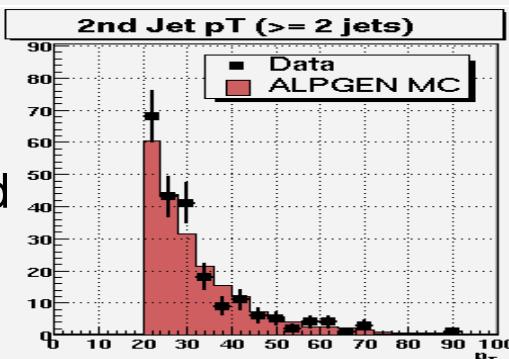
All



1st



2nd



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# Unsmearing



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# Concept

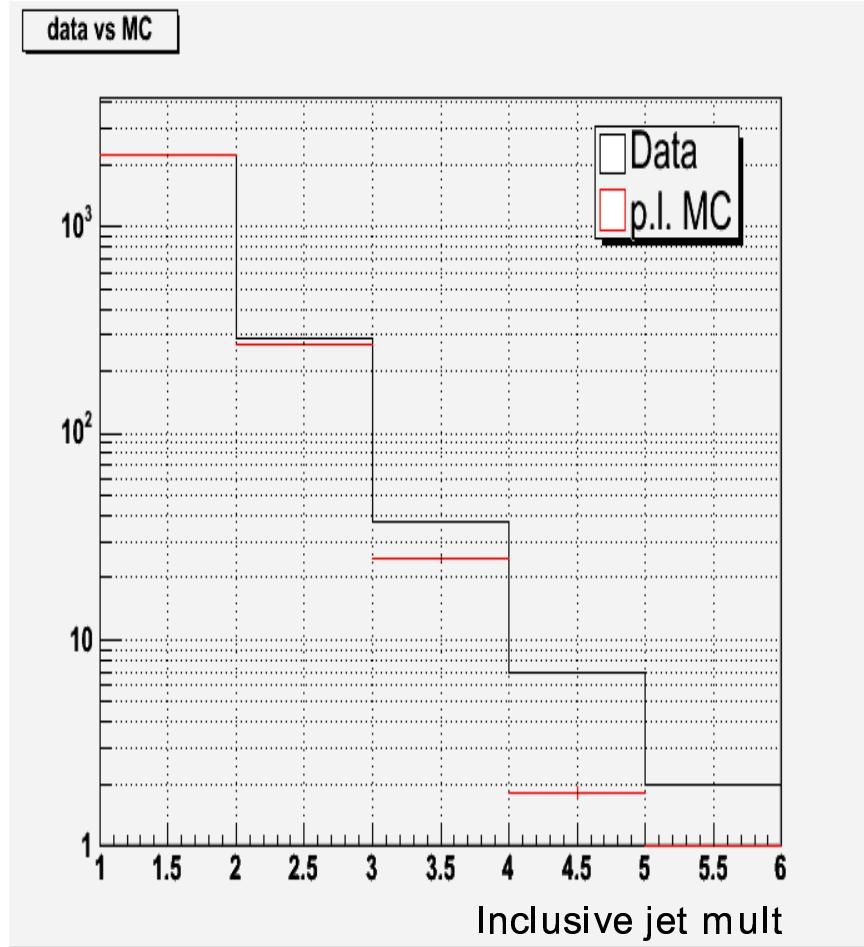
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- Need to unsmear the data jet multiplicity distribution to be able to quote particle level xsections
- We use a Z+j Pythia sample (2-to-2 processes) which only contains particle level jets (no detector simulation)
- To be able to compare to data we smear the jet pT and also apply the jet reco/ID efficiencies
- In MC we ...
  - ... get the inclusive jet multiplicity histogram for particle level jets with  $pT > 20\text{GeV}$  and  $|\text{det\_eta}| < 2.5$
  - ... get the inclusive jet multiplicity histogram for particle level jets with **smeared**  $pT > 20\text{GeV}$  and  $|\text{det\_eta}| < 2.5$
  - ... take the ratio between the two histograms to get the unsmearing coefficients
  - ... apply the unsmearing coefficients to the measured data jet multiplicities in data to unsmear

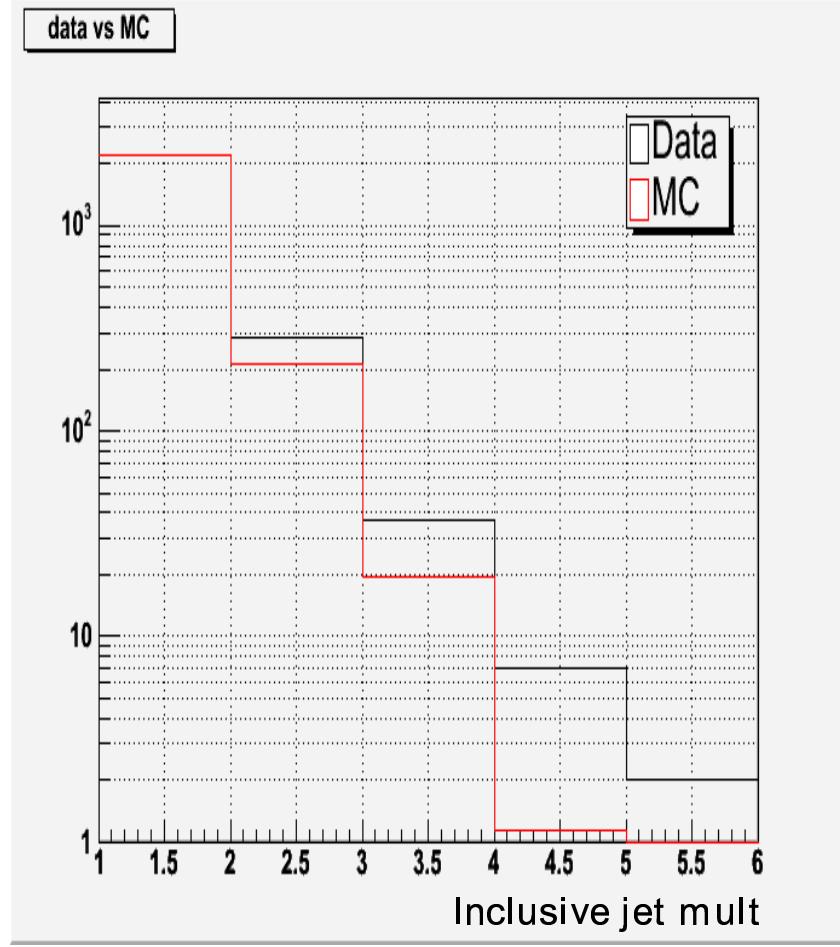


# Comparing jet multiplicities

Comparing data with particle level MC  
(smeared pt & jet reco applied)

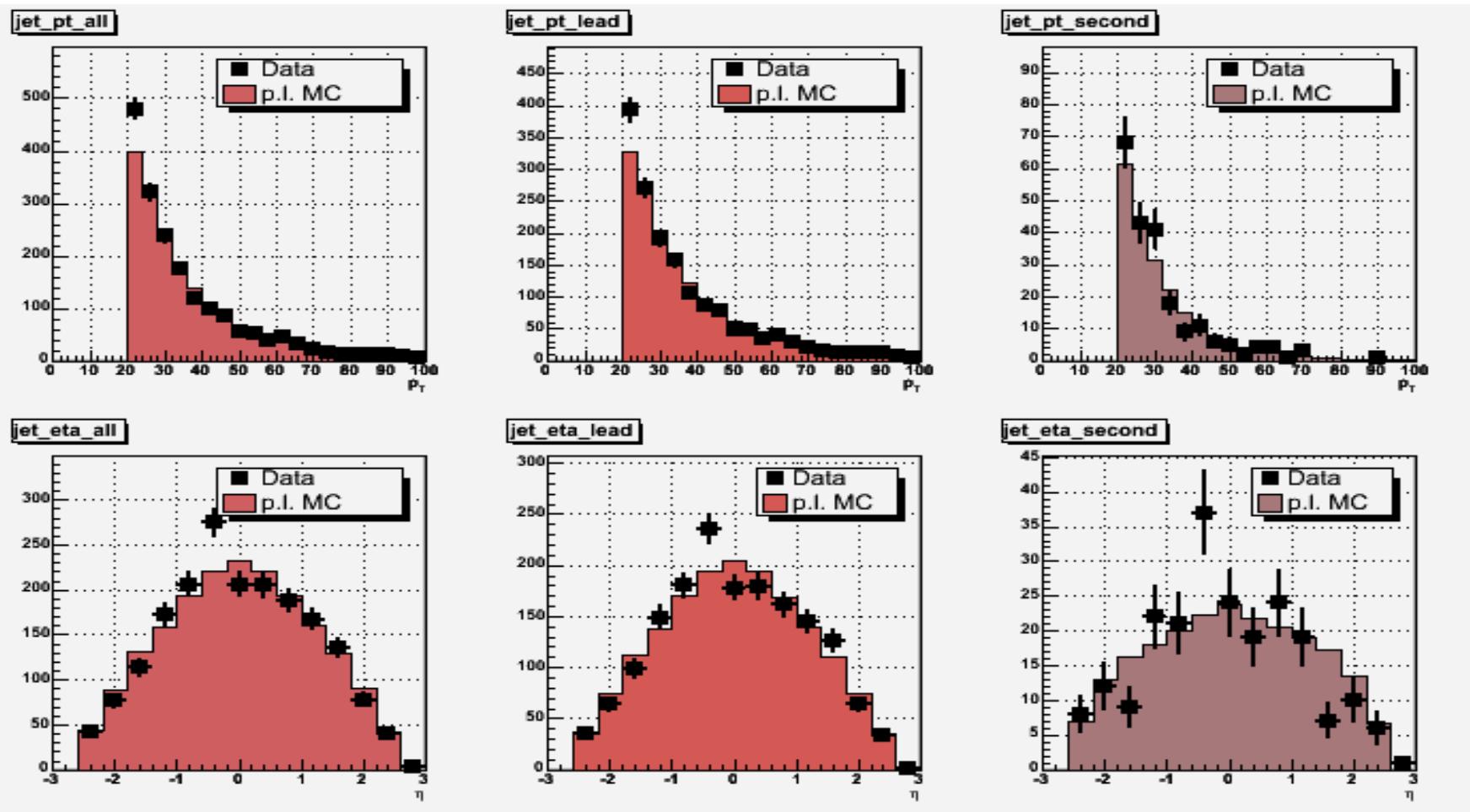


Comparing data with CAL level MC



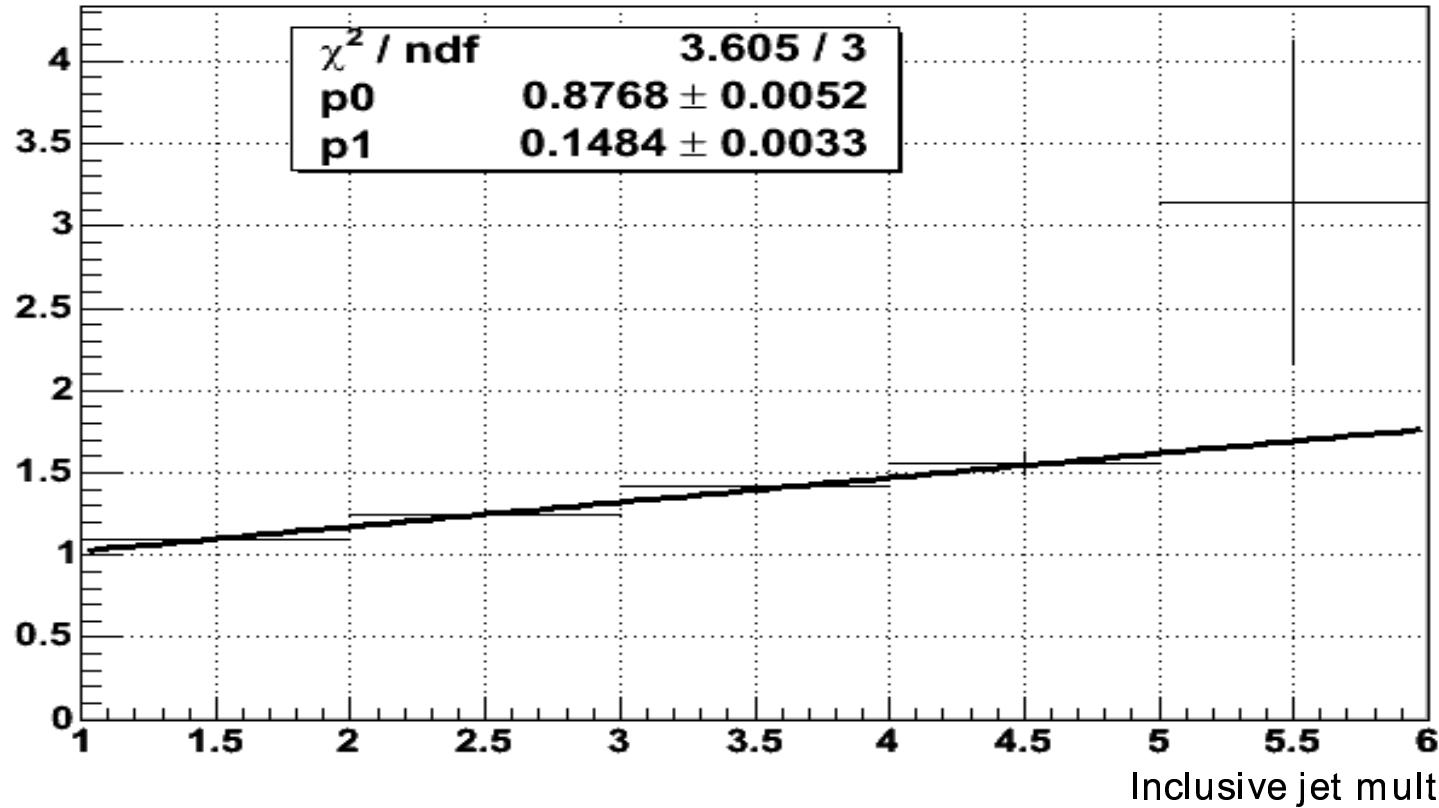
# Jet comparisons

Jet comparisons between data and p.l. MC (smeared & jet reco applied)



# Unsmearing + Jet Reco/ID correction factors

unschmearing\_incl\_h



Jet multiplicity	1	2	3	4	5
Correction factor	1.1	1.2	1.4	1.5	1.7



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# **Z(ee) + $\geq n$ Jet xsections**



# Xsections

Xsection x BR = (# of corrected signal events) / (Lumi x Acceptance)

$$\text{Lumi} = 342.885 \text{ pb}^{-1}$$

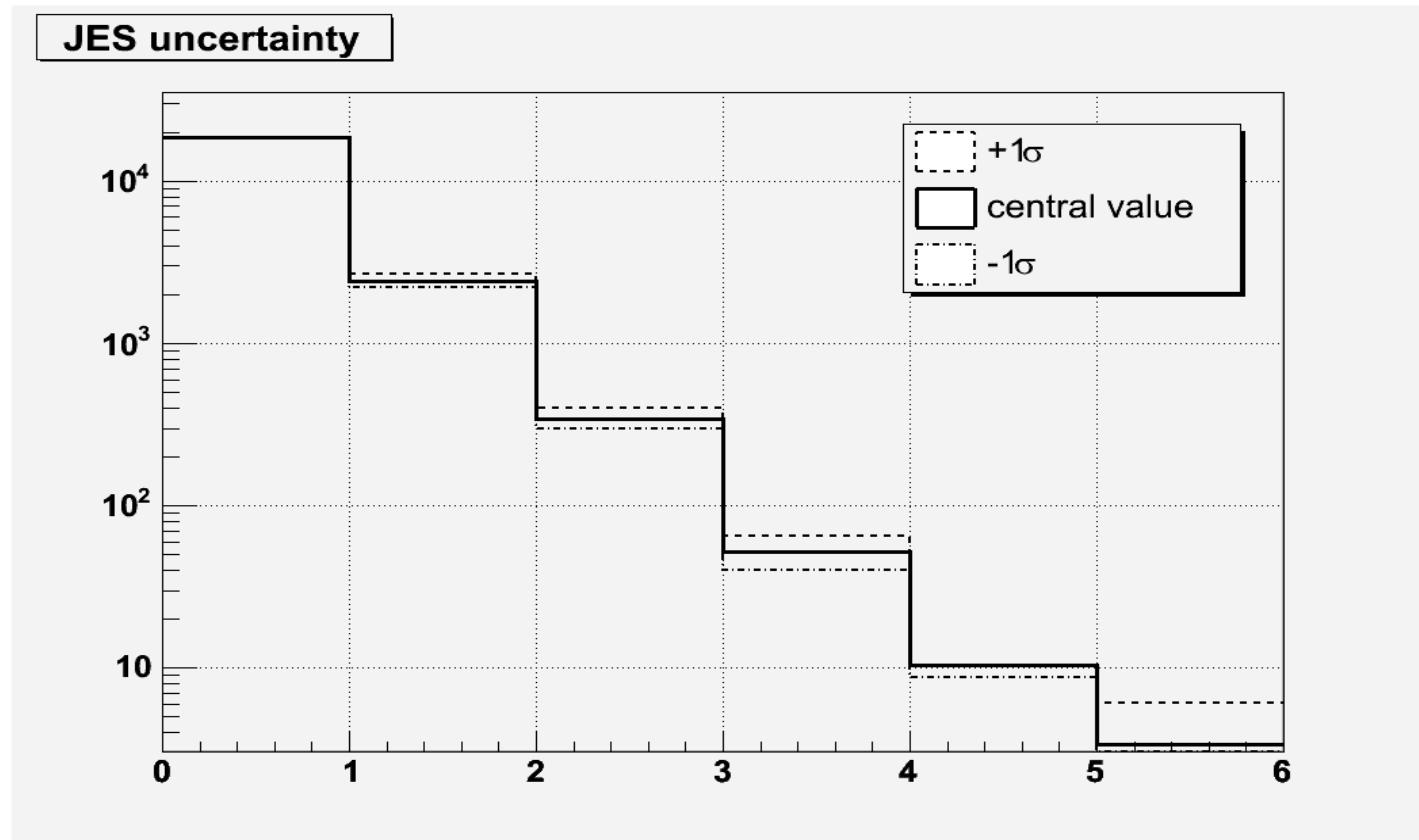
Jetmult	# signal	Acceptance	xsection ( <small>JES uncertainty, Lumi uncertainty</small> )
0	18,551	21.0%	<b>257.6 pb</b> <small><math>\pm 17.9\text{pb}</math></small>
1	2,427.7	23.7%	<b>29.9 pb</b> <small><math>\pm 2.9\text{pb} \pm 2.1\text{pb}</math></small>
2	343.2	25.4%	<b>3.9 pb</b> <small><math>\pm 0.6\text{pb} \pm 0.3\text{pb}</math></small>
3	51.8	27.8%	<b>0.54 pb</b> <small><math>\pm 0.14\text{pb} \pm 0.04\text{pb}</math></small>
4	10.5	28.6%	<b>0.11 pb</b> <small><math>\pm 0.02\text{pb} \pm 0.01\text{pb}</math></small>
5	3.4	30.9%	<b>0.032 pb</b> <small><math>\pm 0.02\text{pb} \pm 0.002\text{pb}</math></small>



# Systematics

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- Luminosity:  $\pm 6.5\%$
- JES:  $\pm 1\sigma$



# Inclusive todo

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- Corrections:
  - Promotion
  - Jet-electron overlaps
  - Vertex correction
  - Bkg contributions from other physics processes
- Systematics:
  - [Unsmearing](#)
  - [Jet Reco](#)
  - Acceptance
  - Corrections
  - Event counting & bkg subtraction
- Comparison to theory:
  - [New matched samples available?](#)
  - [Finish Analysis note](#)